A CONNECTION ASSEMBLY FOR A GRID STRUCTURE

The present invention relates to a connection assembly for a grid structure in which two elongate elements are connected at an intersection and also to a grid structure formed from such connection assemblies. Such structures can be used in various commercial applications but have particular relevance to pallet containers wherein an inner plastic container suitable for transporting liquid substances is enclosed by an outer supporting container comprising such a grid structures.

When used industrially, such pallet containers have to pass governmental approval inspections and fulfill certain criteria. For example, the filled pallet containers have to undergo interior pressure tests and drop tests from specific heights, which are also conducted at extremely low temperatures. The worst case drop is a diagonal drop onto the lower front wall of the pallet container where the bottom valve from the inner plastic receptacle is located.

Another important criterion for governmental approval is the so-called vibration test. To simulate transport vibrations by road or rail the filled pallet containers have to undergo low frequency vibrations for a certain amount of time.

European patent EP-A-0 916 777 discloses a connection assembly wherein first and second elongated elements are connected by providing a receiving opening in the first element through which the second element is passed, the two elements then being connected to one another at one or more positions in the region of their intersection.

It has been found that an outer pallet container made from a grid structure with such connection assemblies can suffer problems when subjected to the aforementioned tests.

In the drop test, the inner plastic receptacle tends to become displaced relative to the bottom pallet and as a result of the kinetic energy generated in impact, especially at the front impact wall and the adjacent lateral surrounding areas, the hollow bars of the grid structure tend to be severely deformed. This is especially true at the cross connections of the grid structure, as the elongate element with the receiving opening is more vulnerable. The thin-walled plastic receptacle can be damaged by the deformed and buckled receiving opening.

In the vibration test, because the tubes of the grid structure are submitted continuously to dynamic displacement forces, in time the hollow tubes or welds tend to break and can damage the thin-walled inner receptacle.

It is an object of the present invention to provide a connection assembly for a grid structure which overcomes or substantially mitigates the aforementioned problems when applied to used in a grid structure for a pallet container of the type described.

According to a first aspect of the present invention there is provided a connection assembly comprising first and second elongate elements connected to one another at an intersection, the first element comprising a tube and defining at least one receiving opening through which the second element is passed, and characterised in that the portion of the first element defining the periphery of the receiving opening protrudes inwards into the tube to define a collar surrounding the second element.

Preferably, the first element defines two aligned receiving openings through which the second element is passed, the portions of the first element defining the peripheries of both of the receiving openings protruding inwards into the tube to define two collars surrounding the second element.

Preferably also, an inner dimension of the or of each collar is dimensioned with respect to an outer dimension of the second element so as to provide a frictional fit of the two elements.

Typically during manufacture, the first element is drilled to define the receiving opening, the diameter of the drilled aperture being less than the diameter of the second elongate element. Thereafter, the drilled aperture is preferably punched to deform the periphery of the aperture so that it is folded inwards into the tube to form the collar and to increase the diameter of the aperture to that of the receiving opening.

In some embodiments, the inner surface of the first element is provided with at least one ridge, the apex of which lies close to or contacts the outer surface of the second element, at which position or positions the first and second elongate elements may be connected to one another. Where the first and second elongate elements are made of metal they may be connected to one another at said one or more positions by welding. Alternatively, if the first and second elongate elements are made of a plastics material, they may be connected to one another by ultrasonic welding, induction welding or melt bonding.

Preferably, the first elongate element is tubular with a substantially circular, elliptical or ovoid cross-section.

The second elongate element may also be tubular with a substantially circular or oval cross-section.

Preferably also, the diameter of the second element is smaller by between 20% to 30% than the diameter of the first element.

According to a second aspect of the present invention there is provided a grid structure comprising a plurality of first elongate, tubular elements arranged in parallel and in a spaced relationship with respect to one another, a plurality of second elongate elements arranged in parallel and in a spaced relationship with respect to one another, the first and second elements intersecting and being connected to one another by means of at least one connection assembly in accordance with the first aspect of the present invention.

The various aspects of the present invention will now be described by way of example with reference to the accompanying drawing, in which:-

Fig. 1 is a grid structure in accordance with the second aspect of the present invention and comprising intersections formed by connection assemblies in accordance with the first aspect of the present invention;

Fig. 2 is a longitudinal cross-section through a first elongate element of each connection assembly shown in Fig. 1;

Fig. 3 is a transverse cross-section along the lines III-III in Fig. 2;

Fig. 4 is a view similar to that shown in Fig. 2 but showing a second elongate element intersecting the first elongate element;

Fig. 5 is transverse cross-sectional view along the line V–V in Fig. 4;

Fig. 6 is a view similar to Fig. 5 but of a T-intersection wherein the second elongate element terminates at its intersection with the first elongate element;

Fig. 7 is a view of the first elongate element similar to Fig. 3 but after a first stage during its manufacture;

Fig. 8 is a view similar to Fig. 4 but showing how the second elongate element can bend out of an alignment perpendicular to the first elongate element;

Fig. 9 is a view similar to Fig. 3 but of a first elongate element forming part of the prior art; and

Fig. 10 is a view similar to Fig. 8 but of a prior art connection assembly.

In the following description, the same numerals are used to refer to those components of the embodiments described which are the same or have the same function as one another.

As shown in Fig. 1, a grid structure 1 comprises a plurality of first elongate, tubular elements 2 arranged in parallel in a spaced relationship with respect to one another and a plurality of second elongate elements 3, which are also arranged in parallel in a spaced relationship with respect to one another. The first and second elements 2 and 3 are connected together at each intersection 4 of the structure 1 via a connection assembly 5 as will now be described with reference to Figs. 2 to 5.

At each intersection 4, the first tubular element 2 defines two aligned receiving openings 6 through which the

second element 3 is passed. The portion of the first element 2 defining the periphery of each opening 6 protrudes inwards into the interior of the tube to define a collar 7 that surrounds the second element 3. It will be appreciated that the diameter d2 of the second element 3 is smaller than the diameter d1 of the first element 2, preferably by between 20% to 30%. For example, the diameter d1 of the first element 2 could be 22 mm and the diameter d2 of the second element 3 could be 16 mm. Although the first and second elements, 2 and 3, may both have a circular cross-section, other constructions are possible wherein the cross-sectional shape of one or both of the elements 2 and 3 is not circular but elliptical or ovoid. In the illustrated examples herein, the second element 3 has a circular cross-section but the first element 2 has a cross sectional shape that is elliptical, d1 being the length of the major axis. Also, whereas the first element 2 is always tubular, the second element 3 can be either of tubular or of solid construction .

It will be appreciated that at all of the intersections 4 shown in Fig. 1 and in Figs. 2 to 5, the first and second elements 2 and 3 cross so that two openings 6 are required in the tubular structure of the first element 2 to permit the second element 3 to pass completely therethrough. However, it will be appreciated that at the ends of the second elements 3, T-shaped intersections 8 can be formed wherein the first element 2 is only provided with one receiving opening 6 and the second element 3 terminates within the tubular structure of the first element 2 after passing through the single opening 6. Such an arrangement is shown in Fig. 6.

In a preferred embodiment at each crossing intersection 4 or T-intersection 8, the inner dimension of the receiving opening 6 formed in the first element 2 is sized with respect to the outer dimension of the second element 2 such that there is no play between the collar 7 and the second element

2. Here, the second element 2 is then inserted through the opening 6 under the application of force to overcome friction between the outer surface of the second element 2 and the inner face of the collar 7. In this manner a non-positive frictional fit is established between the first and second elements 2 and 3 which adds to the mechanical strength of the connection assembly, particularly against bending moments which may arise under load in the plane of the two elements 2 and 3.

As also shown in Figs. 2 to 6, the first element 2 may comprise an inner ridge 9, the apex of which is arranged to lie close to or to contact the outer surface of the second element 2 at a position P1. Although not illustrated, a second, identical ridge could also be provided on the opposite side of the first element 2. The ridge 9 can be formed when making the element 2 by externally applying pressure to form a longitudinal crease or indentation 10. Alternatively, the indentation 10 could be formed only in the regions of the intersections 4 of the two elements 2 and 3. An internal ridge 9 could also be formed within the tubular structure of the first element during its production process whereby the outer diameter of the element 2 tube would remain substantially circular or elliptical, without any significant external indentation 10 being visible.

As the first and second elements 2 and 3 contact one another at the position P1 where the crest of the inner ridge 9 contacts the outer surface of the second element 3, the two elements 2 and 3 may be connected to one another at this point. Such a connection may be performed by resistance welding for metallic elements 2 and 3 or alternatively by ultrasonic welding, induction welding or melt bonding if the elements 2 and 3 are made of a plastics material.

The openings 6 in the first element 2 can be made by drilling and punching operations as will now be described.

First, an aperture 11 is drilled into the tubular structure of the first element 2, as shown in Fig. 7, for example using flow drill technology. The diameter D2 of the aperture 11 is made less than the diameter D3 of the required receiving opening 6 and is typically less than the diameter d2 of the second element 3. A punch is then used to deform the periphery of the aperture 11 so that it is folded inwards into the tubular structure of the first element 2 to form the inwardly protruding collar 7 and to increase the diameter of the aperture 11 to a required diameter D3. If flow drill technology is used, then the high speed drill heats the metal around the hole so that it can be readily deformed inwardly by a subsequent punching operation to form the collar 7. It will be appreciated that the shape of the aperture 11 and the cross-sectional shape of the punch should be similar to that of the second element 3, and typically are either circular or elliptical.

If a direct comparison is made with a similarly sized and shaped first element 12 of a prior art arrangement as shown in Fig. 9, wherein the periphery of the aperture is not folded inwards and is simply drilled to provide an aperture 13 of a required diameter D1, it can be seen that although D1 and D3 are the same, the prior art element 12 has had much more material removed from its structure to provide the receiving opening. However, the other dimensions of the element 12 remain the same as the element 2, namely the distances x1 and x3 between the outer edge of the indentation 10 and the adjacent edge of the aperture 6 are equal, as are the distances x2 and x4, which comprise the length between the opposite edge of the element 2 and the opposite edge of the aperture 6.

The fact that in less material has been removed from the first element 2 to provide the receiving openings 6 in the present invention than in the prior art arrangement has the advantageous effect that the area around the receiving opening 6 is strengthened. When used in pallet container, during a drop test or in an actual accident situation, the grid structure 1 on the drop side tends to be bent outwards as a result of the weight of the inner of the lower container. This can cause the first and second elements 2 and 3 to bend or buckle but the presence of the inward protrusion of the collar 7 into the structure of the element 2 prevents pointed bends, which could puncture the inner container, from being formed. Also, in the prior art arrangement the area around each receiving aperture is the weakest portion of the element 12 and if the element 12 breaks or cracks on impact, then sharp points can be created which can also puncture the inner container. However, the collar 7 of the present invention reduces the likelihood of breakage of both the first and second elements 2 at the intersections 4 for two reasons. First, if the second element 3 is pushed out of an alignment perpendicular to the first element 2, as shown in Fig. 8, then the collar 7 supports the second element 3 and provides a smooth pivot surface about which the second element 3 can bend rather than the sharp 'knife edge' pivot points provided by the rim of the aperture 13 of the element 12 of the prior art arrangement, as shown in Fig. 10. This means that the second element 3 of the present invention is more likely to bend than break. In addition, the present invention permits the second elongate element 3 to deform to a greater angle $\beta 1$ than the angle $\alpha 1$ of the prior art arrangement. Also, each collar 7 spreads the dynamic forces which occur between the first and second elongate elements 2 and 3 over its surface area so that there are no "knife edge" contacts between the elements 2 and 3.

It will also be appreciated that the provision of the collar 7 strengthens the first element 2 and it is also less likely to crack or fracture in the region of the aperture 6.

In a pallet container, when the inner container is filled, it tends to bulge outwards and apply pressure to the grid structure of the outer container, which in turn will also tend to bulge or deform outwards. However, in the present invention the inwardly protruding collars 7 strengthen the grid structure, reduce bulging and make it more rigid so that it provides a stronger support casing for the thin-walled inner container.

During vibration testing and normal handling, the first and second elongate elements bend inwards and outwards owing to the vibrations applied thereto and the present invention again reduces the likelihood of stress cracking and stress fractures occurring for the same reasons as indicated above.

Hence, the present invention provides a connection assembly and therefore a grid structure which is more able to withstand the strains and stresses imposed on it during testing and use than prior arrangements. When used in an outer container of a pallet container, the present invention therefore provides a greater security to the carried load.